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## Socioeconomic factors, ethnicity and alcohol-related mortality in regions in Slovakia. What might a tree analysis add to our understanding?

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### ABSTRACT

Regional differences in alcohol-related mortality might reflect strong socioeconomic differences between regions. The present study examines the contribution of education, unemployment, income and minority proportion on regional differences in alcohol-related mortality for inhabitants aged 20–64 years. Linear regression analysis and a non-parametric regression tree analysis were used separately for males and females. The unemployment rate and low education appeared as important determinants of regional alcohol-related mortality, while the proportion of Roma and income were not significantly associated with alcohol-related mortality among males in Slovak districts. A district's unemployment rate was assumed to be the strongest predictor of the outcome measure.

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### 1. Introduction

Alcohol is a major determinant of premature death. It has been estimated that alcohol contributes more than 3% to global mortality (Blomgren et al., 2004; Herttua et al., 2007; Mohapatra et al., 2010; Rehm et al., 2007). Alcohol has been part of the European culture for centuries, and Central and Eastern Europe are not different in this respect. Results from a Polish health project (Zatonski et al., 2008) established that 25% of the male life expectancy gap in the 20–64 years age group between the new member states and the old member states of the European Union, and almost 6% of the female gap are due to alcohol. The alcohol-related mortality rate in the new EU member states is more than twice as high as in the old member states of the European Union for men and 40% higher for women (Mackenbach et al., 2007; Rehm et al., 2007; Van Oyen et al., 2007; Zatonski et al., 2008).

The negative impact of alcoholism on human health is indisputable. Although drinking cultures have become increasingly similar in recent years, in different parts of Europe people still prefer different kinds of alcohol (vodka, beer, wine, etc.), and patterns of drinking remain diverse across the continent (northern binge drinking vs. the southern Mediterranean model) (Zatonski et al., 2008). In addition, the quality of alcohol can vary as well: home-made, illicit and surrogate alcohols are likely to have significant health implications (Zatonski et al., 2008). This is especially true for countries of Central and Eastern Europe, which are characterised by higher alcohol consumption and higher values of alcohol-related mortality rates compared with the old member states of the European Union (Western Europe) (Anderson and Baumberg, 2006; Van Oyen et al., 2007; Zatonski et al., 2008).

In Slovakia a combination of two alcohol-related cultures are present. It has many viniculture areas, where alcohol (wine) is integrated into daily life as in Mediterranean countries or France ('wet culture'), but at the same time the consumption rates of spirits are quite high often resulting in intoxication ('dry culture') (Tomcikova et al., 2009).

Not only is the absolute level of alcohol consumption important, but also the relation between socioeconomic status and alcohol. Alcohol-related morbidity or alcohol-induced premature retirement may decrease a person's socioeconomic status before

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death from an alcohol-related cause. There are many studies about the relations between socioeconomic factors and alcohol-related mortality. For the past two decades, studies have consistently shown inequalities in health between socioeconomic groups and between gender, race or ethnicity, geographical areas and other social categories (Benach et al., 2001, 2003; Ginter, 2000; Ginter et al., 2001, 2005; Harrison and Gardiner 1999; Hemstrom, 2002; Huisman et al., 2005; Koupilova et al., 2001; Kunst, 1997; Mackenbach et al., 1999, 2007; Mackenbach, 2006; Makela, 1999; Mustard and Etches, 2003; Nolen et al., 2005; Schnohr et al., 2004; Sepkowitz, 2006; Zatonski et al., 2008). Many existing studies (Harrison and Gardiner, 1999; Hemstrom, 2002; Herttua et al., 2007; Huisman et al., 2005; Kovács, 2008; Menvielle et al., 2007; Schnohr et al., 2004; Van Oyen et al., 2007) are only partial in the sense of considering the impact of one factor or one dimension of inequality (mainly education level, income, social position, social class or occupation) on alcohol-related mortality, and not considering the interrelated impact of several dimensions of variation. Information is generally limited on the social variation in the health of the people in Central and Eastern Europe (Ginter, 2000; Ginter et al., 2001, 2005; Koupilova et al., 2001; Kunst, 1997; Mackenbach et al., 2007; Zatonski et al., 2008). The available data suggests that considerable differences do exist and that the process of economic and political transition generally tends to lead to an increase in income inequalities and consequently health inequalities within countries. The results of these studies confirm that many countries in Central and Eastern Europe and the Baltic regions have much larger inequalities and alcohol-related mortality than the European average.

Although international differences in alcohol-related mortality have been established, partly related to measures of national prosperity (Mackenbach et al., 2007; Menvielle et al., 2007; Rehm et al., 2007; Vrana, 2007; Zatonski et al., 2008), less is known about subnational geographical variations at the small-area level (Benach et al., 2001, 2003), which is important for reviewing and explaining differences between areas within a country and to formulate area-tailored preventive policies.

Accompanying the changes in political and social conditions in the Slovak Republic starting in 1990, there was a strong change in the demographic trend, which may be characterised as a transition to a new model of reproductive behaviour. Since that time, the period of mortality stagnation has ended and life expectancy for both sexes has increased.

At the same time the most significant economic change after “Velvet Revolution” in 1989 was an increase of unemployment. Until 1989 the Slovak Republic had practically a zero unemployment rate and nearly no experience with unemployment at all. After 1989 the unemployment rate was about a 16% in 1998. The unemployment rate then began to drastically drop and continued

to show a decreasing tendency until the end of the year 2007 till about 8.0%, until the onset of the economic crisis, when the unemployment rate again increased to 12.7% in the year 2009.

The aim of the present work was to study the geographic distribution of alcohol-related mortality in the 20–64 years age group by gender and by small area and to assess the associations between socioeconomic factors and ethnicity and alcohol-related mortality in all districts of the Slovak Republic.

## 2. Methods

### 2.1. Study population

The study population covers all the inhabitants of the Slovak Republic aged 20–64 years in the period 2001–2003. The selected age group is primarily associated with the labour market; it is the economically active population. This part of the population has relatively the lowest mortality rate by age, has finished the process of education and receives a certain kind of income, either salary or social security benefits.

In the period 2001–2003 the average number of inhabitants aged 20–64 years in the Slovak Republic as of July 1st was 3,332,789 people (49.4% men). The total number of alcohol-induced deaths among those aged 20–64 years over the three-year period was 9732 (77.4% men), or 3244 per year on average.

To be able to explore regional differences, the study population was analysed at the district level using an ecological study design. The Slovak Republic is divided into 8 regions at regional level NUTS 3 and deeper into 79 districts at local level LAU 1, 5 of which constitute the capital city Bratislava and 4 the second largest city, Košice. The mean number of inhabitants aged 20–64 per district is 42,187 persons, with values ranging from 7347 to 102,582 inhabitants (average for the period 2001–2003).

### 2.2. Data

The data consist of absolute population numbers and numbers of alcohol-related deaths by gender in the districts of the Slovak Republic in the period 2001–2003 and were obtained from the Statistical Office of the Slovak Republic (Mortality by age and causes of death, 2004a). A complete list of causes of death attributable to alcohol-related mortality, according to the International Classification of Disease (ICD-10) from the year 1996, is presented in Table 1 (Harrison and Gardiner, 1999; Hemstrom, 2002; Hoyert et al., 2006). The selected causes of death in our study were known to be caused directly by alcohol consumption, while providing the best correlation with the alcohol-related causes

**Table 1**  
Causes of alcohol-related death.

Official cause of death	ICD-10 codes	Group of causes in Slovak statistics
Alcohol-related pseudo-Cushing's syndrome	E24.4	Not observed
Mental and behavioural disorders due to alcohol use	F10	F10-F19
Degeneration of nervous system due to alcohol	G31.2	Other causes from Chapter VI
Alcoholic polyneuropathy	G62.1	Other causes from Chapter VI
Alcoholic myopathy	G72.1	Other causes from Chapter VI
Alcoholic cardiomyopathy	I42.6	I30-I52
Alcoholic gastritis	K29.2	Other causes from Chapter XI
Alcoholic liver disease	K70	K70-K76
Alcohol-related chronic pancreatitis	K86.0	Other causes from Chapter XI
Finding of alcohol in blood	R78.0	Not observed
Accidental poisoning by and exposure to alcohol	X45	X40-X49
Intentional self-poisoning by and exposure to alcohol	X65	X60-X84
Poisoning by and exposure to alcohol, undetermined intent	Y15	Other causes from Chapter XX

Chapter VI—Diseases of the nervous system; Chapter XI—Diseases of the digestive system; Chapter XX—External causes of morbidity and mortality.

of death classified in the Slovakian statistical system. This directly alcohol-related mortality is considerably less than the total mortality attributable to alcohol but avoids the problems inherent in employing alcohol attributable fractions, which may vary by population subgroups. In the Slovak Republic regional statistics on mortality by cause of death are only available in main chapters and groups of causes within them; they are not available separately by individual cause. Therefore, the analyses included all groups of causes of death in which the particular alcohol-related causes from the above mentioned list figured; two alcohol-related causes of death are not separately observed in the Slovak Republic.

Educational level, rate of unemployment, income and the proportion of Roma population in a district were used as socio-economic indicators influencing the mortality rate. All indicators were calculated for each district. These indicators are of interest for the population in the age group 20–64 years, that is, the potentially economically active population primarily associated with the labour market. This age group has a relatively higher alcohol-related mortality rate by age, has finished the process of education and receives a certain kind of income (salary or unemployment benefits).

Educational level by gender, using the percentage of inhabitants aged 20–64 years having tertiary education, was based on the 2001 population census from the Statistical Office of the Slovak Republic (Population and Housing Census, Population by education, 2002). Numbers of unemployed by gender were obtained from the tally of the Centre of Labour, Social Affairs and Family of the Slovak Republic. The rate of unemployment was expressed as the proportion of the number of unemployed inhabitants aged 20–64 years to the total number of inhabitants by gender in the period 2001–2003 (Monthly Statistics of unemployment, 2009). Income level (average monthly gross income in Slovak Crowns (SKK)) was based on data from the Statistical Office of the Slovak Republic. At the district level income data are available only in the form of gross income (net income is about 75% of gross income) and only for companies with 20 and more employees (about 60% of all companies in the country) (The Regional Statistical Yearbook of Slovakia, 2007). The percentage of the Roma population living in settlements was obtained from the sociographic mapping conducted by the Office of the Government Plenipotentiary for Roma Community from the year 2004 for both sexes together (Sociographic mapping of Roma communities in the Slovak Republic, 2004b) (Table 2).

### 2.3. Measures of mortality

Using the regional mortality data, the standardised alcohol-related mortality rate was calculated. For each region the mortality by 5-year age-groups (20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59 and 60–64) and total alcohol-related mortality rate by gender were calculated. Regional mortality

rates were standardised by direct method of standardisation and by age using the Slovak population as the standard. Mortality rate is expressed as the number of deaths per 100,000 inhabitants.

### 2.4. Maps

Using the regional standardised alcohol-related mortality rates and data by socioeconomic indicators, maps were constructed. The range of the indicators on the maps was divided into quartiles.

Maps were done using ArcView.

### 2.5. Statistical analysis

The effects of education (the proportion of inhabitants with tertiary education in the region), unemployment (the average unemployment rate in the region), income (the average monthly gross income in the region) and the Roma population (the proportion of the population in the region's settlements) on regional differences in standardised alcohol-related mortality were explored using two statistical methods: firstly, non-parametric regression tree, and secondly the transformed linear regression (initially the crude effect of each factor separately was explored and then all factors were included into the final model). Both analyses were done separately for males and females. The regression model was checked for collinearity.

The standardised mortality rates were transformed using the arcsine-transformation, which is more consistent with statistical theory, because the transformation of a proportion results asymptotically in a normally distributed response (Zar, 1996) according to:

$$\arcsin\left(\sqrt{\text{mort}(\%)}\right) = f(\text{vars})$$

Regression tree models are tools used to explore the interactions between a desired outcome and its determinants, in this case male and female standardized mortality rates and a set of variables. The building of a regression tree begins with a root node containing all the subjects and then through a process of yes/no questions to generate descendant nodes. Beginning with the first node, a regression tree finds the best possible variable to split the node into two child nodes. In order to find the best variable, the software checks all possible splitting of variables (called splitters), as well as all possible values of the variable to be used to split the node (Speybroeck et al., 2004; Steinberg and Colla, 1995). In choosing the best splitter, the programme seeks to maximise the average “purity” of the two child nodes. For a continuous target variable like standardized mortality rates, the mean squared error of within-node dispersion is used as the measure of impurity. The general idea, therefore, is to find nodes with minimal within-variance (i.e. grouping areas with similar standardized mortality rates). The main goal of the regression tree is then to create homogeneous groups. The independent variables are the proportion of inhabitants with tertiary education, the unemployment rate, the percentage of Roma population and income.

Analyses were done using SPSS version 15.0.

## 3. Results

### 3.1. Mortality

In the period 2001–2003 the standardised mortality rates for the total population aged 20–64 years in the Slovak Republic were 628.0 deaths per 100,000 inhabitants for males and 243.5 deaths per 100,000 inhabitants for females. The proportion of alcohol-related deaths in this period was 24.2% for males and 17.9% for

**Table 2**

Basic data for the Slovak population—averages for the period 2001–2003.

	Males	Females	Total
Mortality for alcohol-related causes (aged 20–64 years, per 100,000 inh.)	152.0	43.5	97.1
Education tertiary <sup>a</sup>	12.6%	11.2%	11.9%
Unemployment rate	15.2%	12.2%	13.7%
Income	€539	€397	€468
Roma <sup>b</sup>			5.3%

<sup>a</sup> Population census, 2001.

<sup>b</sup> Sociographic mapping 2004.



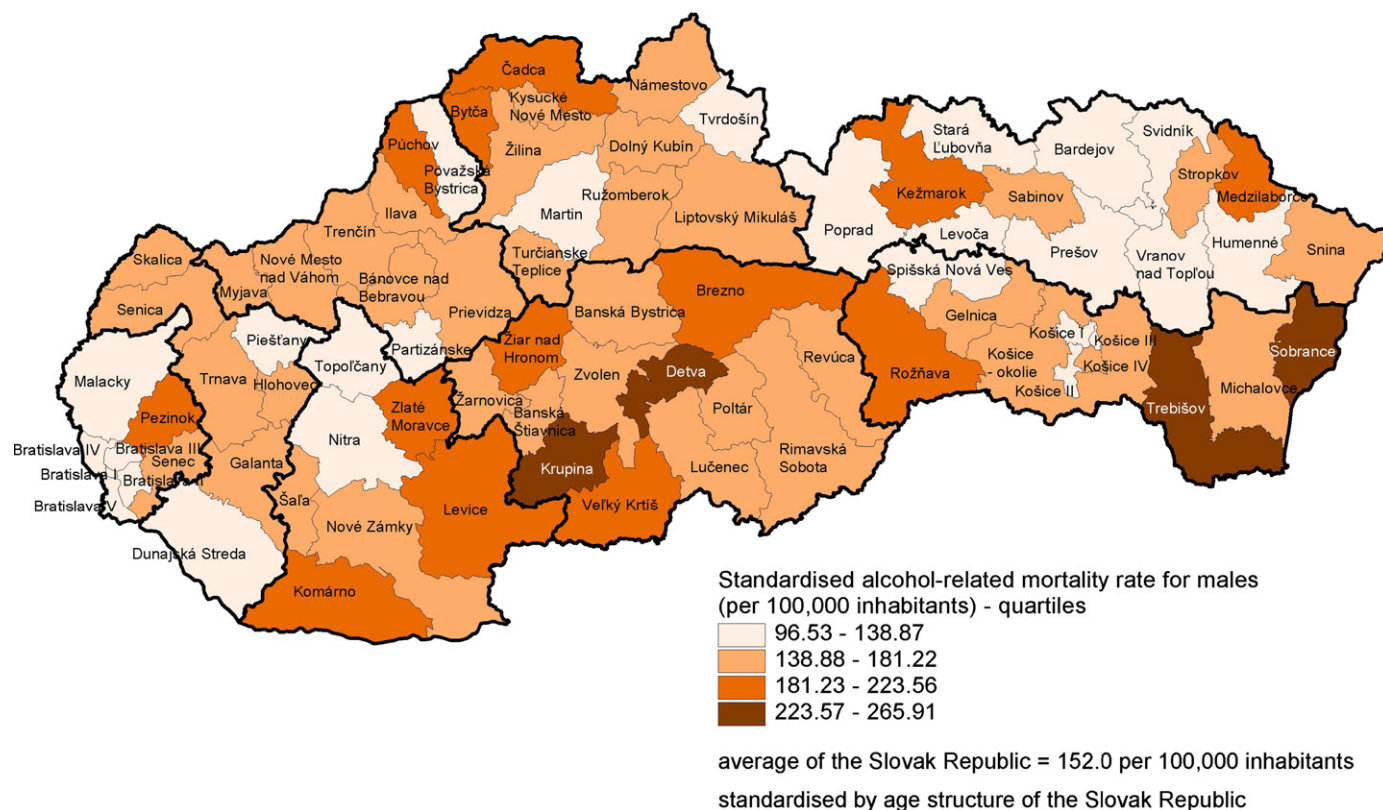


Fig. 1. Standardised mortality rates for alcohol-related deaths for males aged 20–64 years by districts in the Slovak Republic.

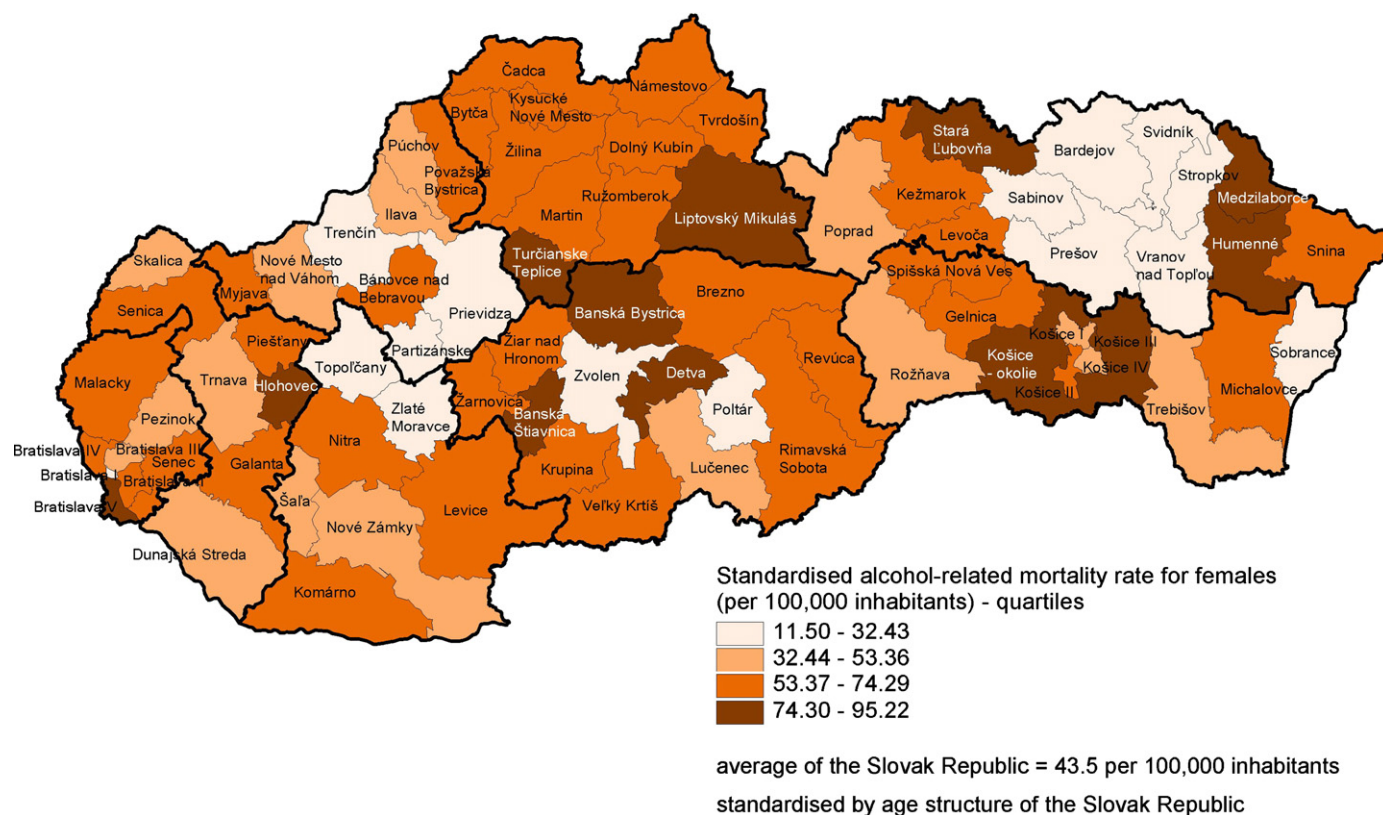


Fig. 2. Standardised mortality rates for alcohol-related deaths for females aged 20–64 years by districts in the Slovak Republic.

females. The standardised alcohol-related mortality of inhabitants aged 20–64 years by gender in the districts of the Slovak Republic in the period 2001–2003 is shown in Figs. 1 and 2.

The average alcohol-related mortality rate among the male population is 152.0 deaths per 100,000 inhabitants, ranging from 96.5 to 265.9 deaths per 100,000 inhabitants. Districts in the central

and southern parts of Central Slovakia are among those with the highest standardised alcohol-related mortality rate for males aged 20–64 years. In contrast, districts in the northern part of Eastern Slovakia and the central part of Western Slovakia are among those with the lowest standardised alcohol-related mortality rate for males in that age group. Compared with the standardised alcohol-related mortality rate for males aged 20–64 years at the national level, half of the districts (41 out of 79) achieved a lower alcohol-related mortality rate than the average rate for the Slovak Republic (Fig. 1).

The standardised alcohol-related mortality rate for females aged 20–64 years in the examined districts showed less marked inequalities; the difference between the marginal values is 83.7 deaths per 100,000 inhabitants (minimum value 11.5, maximum value 95.2 deaths per 100,000 inhabitants). Higher alcohol-related mortality rates for females are markedly evident in the districts of Western, Southern and Central Slovakia. Half of the districts (41 out of 79) attained a lower standardised alcohol-related mortality rate for females aged 20–64 years than the average national alcohol-related mortality rate, being 0.4‰ in the period 2001–2003 (Fig. 2). There are smaller differences compared to those in males, and the variance between the district with highest standardised alcohol-related mortality rate and the average for the Slovak Republic was 51.7 deaths per 100,000 inhabitants for females (113.9 deaths per 100,000 inhabitants for males).

### 3.2. Regression tree

The aforementioned regression analysis is further completed by a regression tree analysis, which helps shed additional light on

the impact of determinants on standard mortality rates. Here, the main aim was to discover possible relationships between determinants in their influence on standardised mortality rates, which are not obvious at first sight.

The regression tree reports the results for standardised mortality rates for male as a continuous target variable. Results are shown in Fig. 3, an analogue for the regression model. A regression tree methodology also provides a ranking based on the overall contribution of each variable in the construction of the tree. This ranking indicates the importance of each independent variable as a predictor. Importance, for a particular variable, is the sum across all nodes in the tree of the improvement scores between this variable and the best splitter at a particular node (Protopopoff et al., 2009). It is thus possible that a variable enters the tree as a second most important splitter in many nodes (and will not appear on the tree), but never as the primary splitter (Thang et al., 2008). However, such variable will turn out as very important in the overall variable ranking. The advantage of such an approach is that important contributing determinants are not ignored. In our case, unemployment rate was for example selected as being the most important, although tertiary education was used as the first split, followed by tertiary education, the proportion of the Roma and income. The obtained "Purity" was not increased by further splitting using any of the available variables. The starting (root) node holds the 79 districts with an observed average male standardised mortality rate (the target variable) of 1.56. The proportion of inhabitants with tertiary education proved to be the first splitter, at a cut-off point of 8.8%. Districts above this cut-off point show lower standardized mortality rates (average = 1.40). For the districts with low levels of the tertiary education (< 8.8%), the proportion of the Roma was the next splitter at a threshold of 9.11.

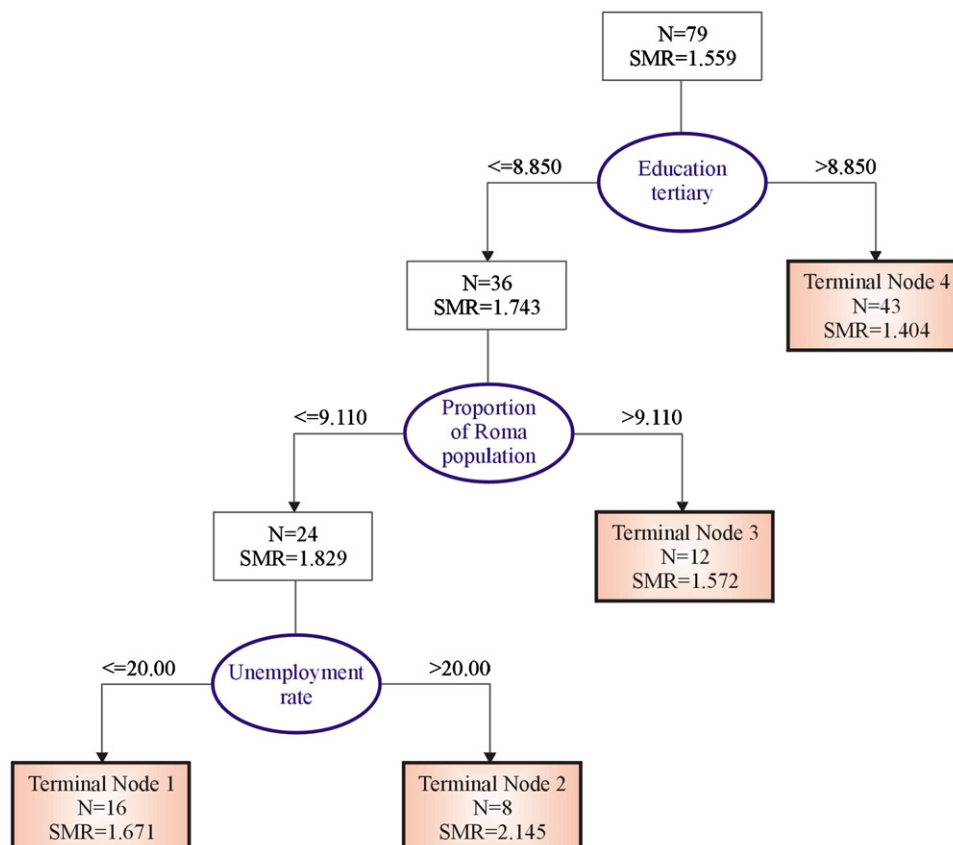


Fig. 3. Regression tree of standardised mortality rates for alcohol-related deaths for males.

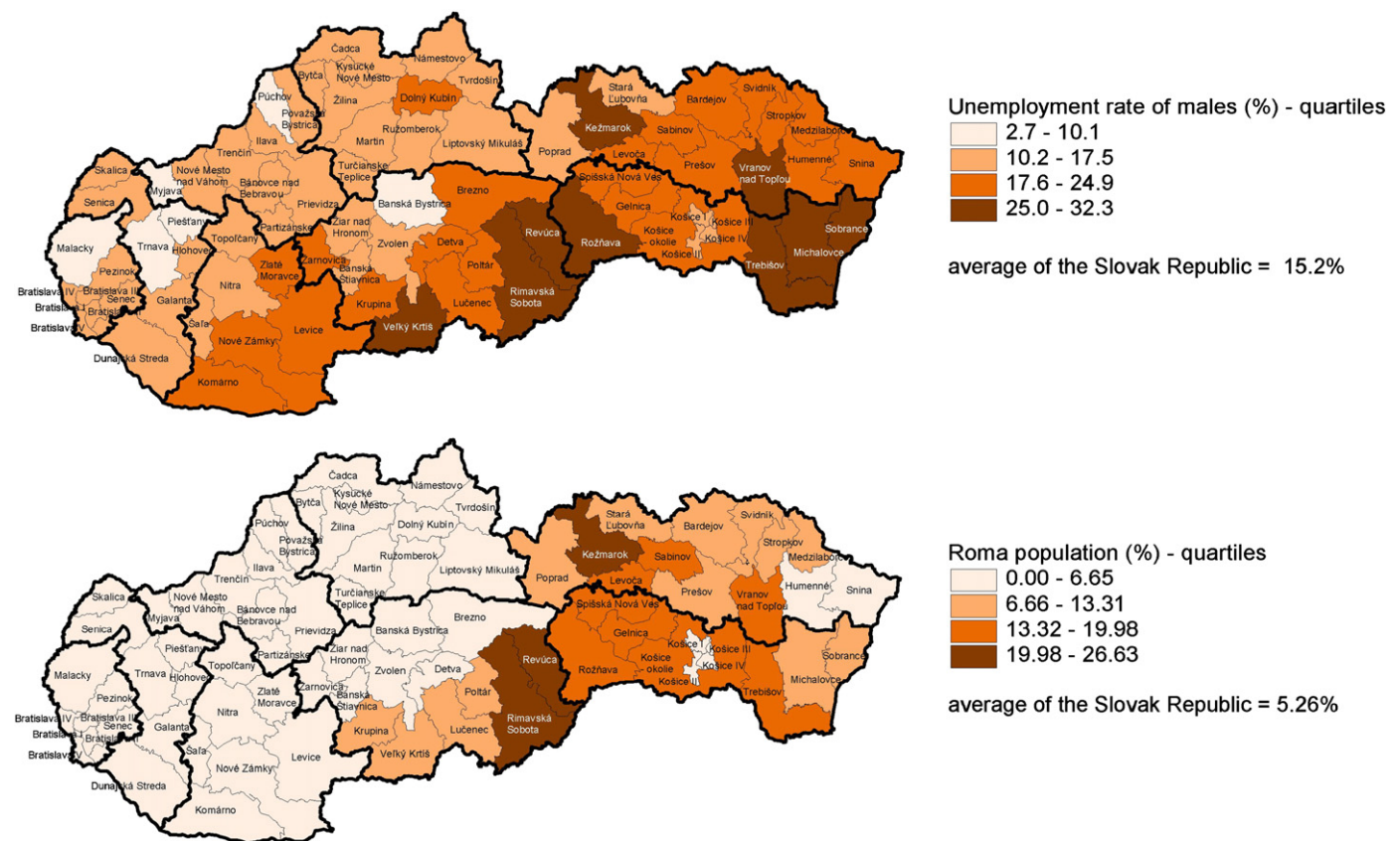


Fig. 4. The unemployment rate of males and the percentage of the Roma population living in settlements by districts in the Slovak Republic in the year 2004.

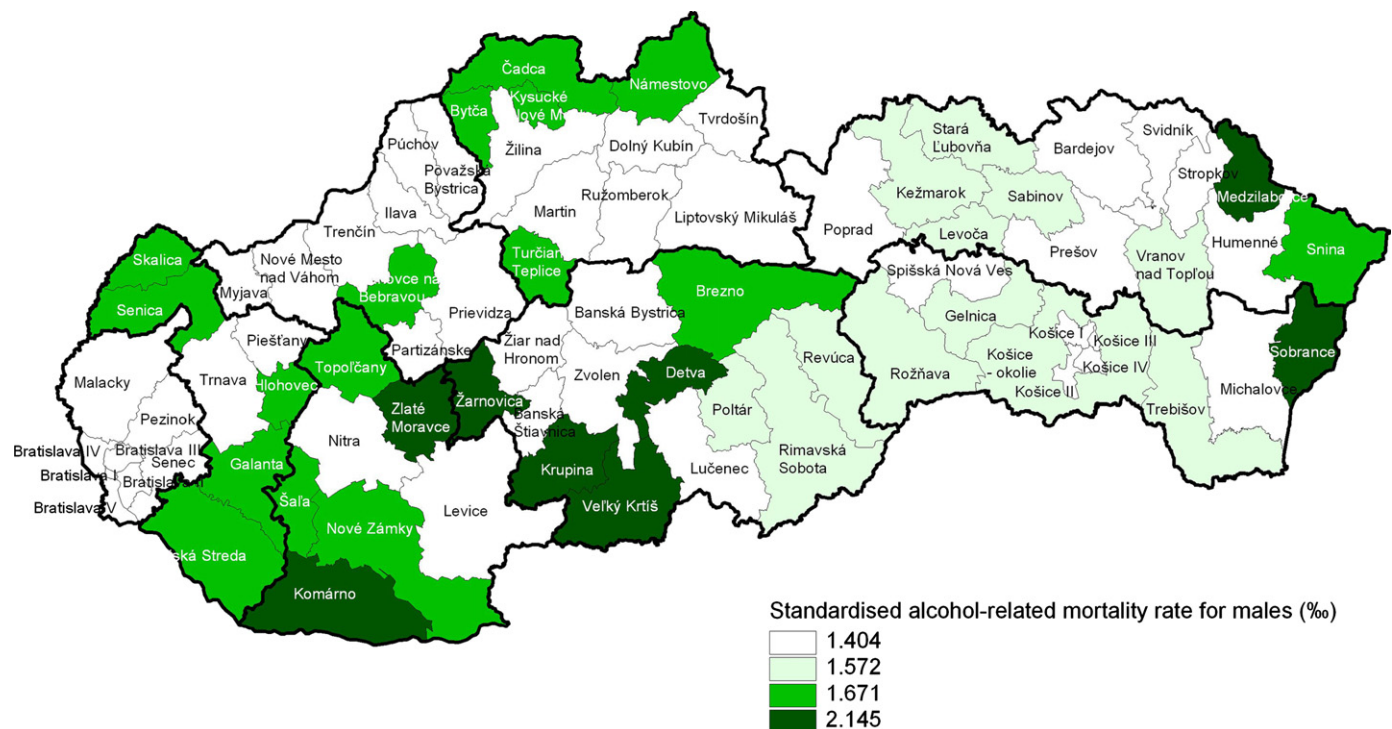


Fig. 5. Standardised mortality rates for alcohol-related deaths for males aged 20–64 years by districts in the Slovak Republic grouped by terminal nodes derived from the regression tree analysis.

Fig. 4 shows the regional distribution of a selected socio-economic indicator and ethnicity in the districts of the Slovak Republic.

The districts with a low proportion of tertiary education and those with a high proportion of Roma (>9.11) have on average lower standardized mortality rates for alcohol-related deaths



(average = 1.57). Unemployment is then used to split the districts with a relatively low proportion of the Roma. In contrast, districts with a proportion of inhabitants with tertiary education < 8.8%, a proportion of Roma inhabitants fewer than 9.11% and low unemployment rate levels (< 20%) form terminal node 1 and have an average standardised mortality rate of 1.67. Districts with a proportion of inhabitants with tertiary education < 8.8%, a proportion of Roma inhabitants less than 9.11% and relatively higher unemployment rate levels ( $\geq 20\%$ ) form terminal node 2 and have an average standardised mortality rate of 2.15. The summary boxes for the terminal nodes provide 4 categories of standardised mortality rate, having average levels of standardised mortality rate of 1.40 (terminal node 4), 1.57 (terminal node 3), 1.67 (terminal node 1) and 2.15 (terminal node 2). Districts can thus be grouped into these 4 groups, as shown in Fig. 5.

For the female standardised mortality rates, the optimal tree had no splits and only one node, the root node. This indicates that the available variables were not helpful in the creation of homogenous groups; in other words, they are not strongly related to female standardised mortality rates.

### 3.3. Linear regression

Table 3 presents the results of the linear regression of the standardised alcohol-related mortality rates in the districts of the Slovak Republic and the separate socioeconomic indicators. In this model the variables were entered consecutively, to explore the

**Table 3**  
Linear regression between standardised mortality rate for alcohol-related deaths and socioeconomic indicators (separately).

Socioeconomic indicators (separately)	Male			Female		
	Standardised coefficients ( $\beta$ )	Sig.	R2	Standardised coefficients ( $\beta$ )	Sig.	R2
Education tertiary	-.426	.000***	.182	-.004	.971	.000
Unemployment rate	.362	.001**	.131	.000	1.000	.000
Income	-.334	.003**	.111	.083	.467	.007
Proportion of Roma population	.063	.583	.004	-.067	.557	.004

R2—explained variance.

\*\*  $p \leq .01$ .

\*\*\*  $p \leq .001$  (2-tailed).

**Table 4**  
Linear regression between standardised mortality rate for alcohol-related deaths and socioeconomic indicators (together).

Socioeconomic indicators (together)	Male		Female	
	Standardised coefficients ( $\beta$ )	Sig.	Standardised coefficients ( $\beta$ )	Sig.
Education tertiary	-.445	.011*	-.409	.126
Unemployment rate	.652	.001**	.198	.336
Income	.274	.147	.503	.063
Proportion of Roma population	-.491	.002**	-.187	.286
<b>R2</b>	<b>.303</b>		<b>.056</b>	

R2—explained variance.

\*  $p \leq .05$ .

\*\*  $p \leq .01$  (2-tailed).

effects separately. The dependent variable is the standardised alcohol-related mortality rate by district separately for males and females. The unemployment rate shows a positive significant effect, tertiary education and income show a negative significant effect on the standardised alcohol-related mortality among males; however, none of the four selected socioeconomic indicators contributed to the prediction of the standardised alcohol-related mortality rate among females.

The relationship between the standardised alcohol-related mortality rate for inhabitants aged 20–64 years by gender and the socioeconomic indicators together in the districts of the Slovak Republic as revealed by linear regression is presented in Table 4. The model explores the influence of all variables together on alcohol-related mortality rates. The dependent variable is the standardised alcohol-related mortality rate by district separately for males and females (continuous); the independent variables are selected socioeconomic indicators by district separately for males and females (all continuous). The model explains 30.3% of the variance in standardised alcohol-related mortality rate among the districts for males, and 5.6% of the variance in standardised alcohol-related mortality among the districts for females. The proportion of males with tertiary education, the proportion of unemployed males and the proportion of the Roma population contributed to the prediction of the standardised alcohol-related mortality rate for males in the districts of the Slovak Republic. The lower the proportion of tertiary education and of the Roma population and the higher the unemployment rate, the higher the alcohol-related mortality rate was. However, none of the four selected socioeconomic indicators contributed to the prediction of a standardised alcohol-related mortality rate for females in the districts of the Slovak Republic. Collinearity, and its influence on the model, was also performed. The maximum collinearity index was 27.4, meaning that the model does not seem to have a substantial problem.

## 4. Discussion

Our study points out that the socioeconomic indicators tertiary education and unemployment rate and the ethnic indicator proportion of Roma are associated with the alcohol-related mortality rate among districts in the Slovak Republic in the male population aged 20–64 years. The average monthly gross income does not contribute to this prediction. The proportion of females with tertiary education, the female unemployment rate, income and the proportion of Roma population were not associated with differences in alcohol-related mortality rate between districts. Using tree analyses, the unemployment rate of male aged 20–64 years was assumed to be the strongest predictor of the alcohol-related mortality in the districts in the Slovak Republic, while for females such an analysis could not be performed, indicating that the selected indicators do not contribute to the explanation of the differences in alcohol-related mortality among females.

Most of the published studies dealing with spatial analysis of alcohol-related mortality refer to the significant relationship between regional socioeconomic indicators and alcohol-related mortality rates for both sexes in middle age, higher for men than for women, as in our study (Blomgren et al., 2004; Hemstrom, 2002; Mackenbach et al., 2007; Makela, 1999; Mustard and Etches, 2003; Rehm et al., 2007; Van Oyen et al., 2007; Zatonski et al., 2008). We included only people aged 20–64 in our analyses. This part of the population shows the lowest mortality as a consequence of the typical *u*-curve of mortality by age, so extrinsic factors (especially alcohol) have greater influence on mortality in this group compared with the elderly group, where the effect of diseases on mortality is more predominant.



From the results of our present and previous research (Rosicova et al., 2009) it is clear that for the Slovak population by districts in the 20–64 years age group the greatest risk factor for alcohol-related mortality is a rising unemployment rate in combination with lower education. If the regional unemployment rate in this segment of the population rises above 20%, then the regional alcohol-related mortality rate also markedly rises. The indicator of the proportion of the Roma population in districts of the Slovak Republic has an indirect effect on regional alcohol-related mortality, which is due to their style of living and health status. Several studies have shown that the Roma people have, without distinction to the region in which they live, poor health, lower life expectancy and higher prevalence of many diseases compared with the national average or with the majority population (Filadelfiová et al., 2006; Ginter et al., 2001; Hajioff and McKee, 2000; Kosa et al., 2007; Koupilova et al., 2001). With respect to their shorter average life expectancy, a very high number of Roma probably die at a young age due to cardiovascular diseases, cancer or diseases of the nervous system (Filadelfiová et al., 2006; Ginter et al., 2001), so alcohol is not the primary reason for death. Although some of these studies are individually based, their outcomes will be most probably valid on the district level. Moreover, several studies have found higher rates of diabetes mellitus, hyperlipidaemia, coronary artery disease and obesity in Roma than in the national majority population what might explain the shorter life expectancy in Roma (Hajioff and McKee, 2000; Koupilova et al., 2001; Sepkowitz, 2006). There are also indications that communicable diseases such as hepatitis A and B and higher exposure to parasites, bacteria and viruses are still significant problems for some Roma communities (Hajioff and McKee, 2000; Koupilova et al., 2001).

We found income not to be significantly associated with regional alcohol-related mortality. In the Slovak Republic is regional distribution of income associated mainly with regional disparities connected with economic strength of the regions, where the most developed regions are characterised by the highest income level. Compared with other socioeconomic indicators, regional income is very much prone to reverse causality, whereas regional disparities in education, when education is measured in terms of “highest education achieved”, does not often change in adulthood and is therefore relatively immune to this effect (Blomgren et al., 2004; Harrison and Gardiner, 1999; Hemstrom, 2002; Herttua et al., 2007; Huisman et al., 2005; Mackenbach et al., 1999, 2007; Makela, 1999; Schnohr et al., 2004).

The differences in alcohol-related mortality are much more pronounced for men than for women. In every culture ever studied, men are more likely than women to drink at all and to drink more when they do, with the gap greater for riskier behaviour (Anderson and Baumberg, 2006; Harrison and Gardiner, 1999; Hemstrom, 2002; Herttua et al., 2007; Kovács, 2008; Mackenbach et al., 1999; Meszaros, 2008; Mustard and Etches, 2003; Rehm et al., 2003; Vrana, 2007; Zatonski et al., 2008).

Alcohol-related mortality is twice as high in the new member states as in the old member states of the European Union. In south eastern European countries (Hungary, Romania and Slovenia), but also in the Slovak Republic, liver cirrhosis and alcohol-related cancer mortality are the main alcohol-related health problems (Mackenbach et al., 2007; Rehm et al., 2007; Van Oyen et al., 2007; Zatonski et al., 2008). Results from a Polish health project (Zatonski et al., 2008) established that two factors may induce higher alcohol-related mortality in the eastern part of Europe (so also in Slovakia), such as differences in patterns of drinking spirits, especially the prevalence of irregular heavy drinking occasions, and the composition of alcoholic beverages. In many new member states of the European Union, there is a long tradition of home-made alcoholic beverages. This type of alcohol contains substances which are characterised by higher liver toxicity and is typical for districts in the east and central parts of the Slovak Republic, where alcohol-mortality rates have increased in recent years (Meszaros, 2008).

#### 4.1. Strengths and limitations of the study

The strengths of our study are the area-based design and age specification of the population. Using an ecological design of the study is strongly related to the continuous availability of data at area level, in contrast with those at individual level. The ecological study uses data that generally already exists and is a quick and cost efficient approach compared to individual level studies. It is also particularly valuable when an individual level association is evident and an ecological level association is assessed to determine its public health impact (Morgenstern, 1998).

In many European countries individually-based data on alcohol-related mortality by age are not available, while area-based data are mostly available and comparable. Focusing on lower geographical level (e.g. areas, regions, districts) seems to be more accurate than country comparisons or state level analysis, but studies based on subnational entities are less common (Blomgren et al., 2004).

The limitations of the present study arise from the deficient databases of income and of the proportion of Roma population. Income (average monthly gross payment) is available only for companies with 20 or more employees at the district level in Slovakia. The proportion of such enterprises is about 60%, although the total number of enterprises cannot be determined due to unavailable data. This phenomenon probably explains the lack of significance in our results regarding the relationship between income and alcohol-related mortality rate for people aged 20–64 years in the districts of the Slovak republic. We focused on the population living in Roma settlements, but this definition did not include the whole variety of the Roma population.

#### 4.2. Implications

Some previous studies dealing with alcohol-related mortality and socioeconomic inequalities in European countries have examined this association primarily at the individual level. In the present study, we wanted to explore regional differences, so we carried out the analyses using data at the district level. This study is a spatial analysis of alcohol-related mortality, which includes all alcohol-induced deaths in a particular period in all districts of the Slovak Republic.

Our results indicate the great need for continuation with further analyses of alcohol-related mortality and its determinants. In a follow-up study alcohol-related mortality should be analysed in relation to other socioeconomic factors like social class, regional GDP and the regional Gini-index. Furthermore, it would be interesting to study how the relationships between alcohol-related mortality and separate socioeconomic factors change over time.

Most alcohol-related mortality in new member states of the European Union could be reduced if alcohol control policies known to be both effective and cost-effective were not merely formulated but also implemented. Stressing the social unacceptability of binge drinking, protecting young people against alcohol, protecting people other than the drinker and mobilising public support so that help is available for people with problems are all among recommendations for alcohol policy. However, such policies require changes in the approach towards alcohol, creating challenges for societies and consequently for governments (Zatonski et al., 2008).

In the Slovak Republic, unlike the legislative steps taken in recent years leading to a restriction on smoking in public and to a health protection of nonsmokers, in the field of the alcohol consumption still lacks an effective actions which would have a positive impact on health of inhabitants. Implementation of the existing age restriction to buy alcohol (> 18 years) would be among the first policies to do; and as alcohol is cheaper than soft

drink, politicians should consider the tax instrument to be used in the fight against avoidable alcohol-related mortality.

### Conflict of interest statement

None.

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